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ENHANCING AGRICULTURAL SUSTAINABILITY IN PAKISTAN: ADDRESSING CHALLENGES AND SEIZING OPPORTUNITIES THROUGH EFFECTIVE PLANT DISEASE MANAGEMENT

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ABSTRACT

Pakistan's agricultural sector is essential for the country's economy, food security, and poverty reduction. However, it faces challenges such as water scarcity, land degradation, low productivity, climate change and infestation of pests and diseases. Addressing these challenges requires targeted interventions such as better soil management practices, improved access to high-quality seeds, and efficient water management practices. Pest and disease management is a crucial component of successful crop production. Effective management involves a range of tactics, including integrated pest and disease management, cultural practices, resistant crop varieties, and proper pesticide use. However, there are concerns about the potential negative impacts of chemical pesticides, highlighting the need for more sustainable and environmentally friendly alternatives. By combining different control methods and tailoring them to specific situations, farmers can minimize economic losses and improve crop productivity while promoting environmental sustainability and human health. It is important to continue researching and developing new pest and disease management strategies to ensure that farmers have access to the most effective and sustainable practices. Smallholder farmers must be made aware of these practices and provided with education, subsidies, and credit. Implementing these measures can increase productivity, improve incomes, and contribute to the country's economic development.

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INTRODUCTION

According to the Pakistan Bureau of Statistics, agriculture contributes around 24% to the country's GDP and employs almost half of the population (Anonymous, 2022). Pakistan is also one of the largest producers of several major crops, such as wheat, cotton, sugarcane, rice, and maize (FAO, 2023). These crops provide a significant portion of the country's food supply and are major exports for the country (GoP, 2020). In addition to food production, agriculture also contributes to other industries, such as textiles and manufacturing, through the supply of raw materials. The agriculture sector also provides employment opportunities for people in related industries such as agro-processing, packaging, and transportation (FAO, 2017). However, the agriculture sector in Pakistan also faces significant challenges e.g.

1. Plant diseases have a significant impact on crop

production and can affect farmers, consumers, and the environment.

2. Smallholder farmers often face challenges in accessing high-quality seeds directly affecting their crop yields and profitability.

3. In Pakistan, agricultural soils are nutrient deficient. These deficiencies limit crop yields and reduce overall agricultural productivity.

4. Water resources are limited and under increasing pressure due to climate change, population growth, and urbanization.

5. One of the critical issues in the agriculture industry is the significant wastage of produce after harvesting. This problem not only leads to economic losses for farmers but also contributes to food insecurity and environmental degradation.

Description of these challenges is as under:

Impact of Plant diseases on crop production

While the importance of plant health is widely acknowledged, it is often overshadowed in the One Health literature. It is crucial to recognize that healthy plants play a vital role in human and animal well-being. Plants serve as the primary source of nutrition for both humans and livestock, providing over 80% of the food consumed by humans. However, the availability and safety of plants for consumption are frequently threatened by plant diseases and pests.

The impact of plant diseases on global food production is staggering. Yield losses of significant staple crops can reach up to 30%, resulting in the loss of hundreds of billions of dollars' worth of food production (Rizzo et al., 2021). These losses not only affect the quantity of food available but also pose risks to its safety and quality (Nazarov et al., 2020). Addressing plant health is crucial for ensuring a sustainable and secure food supply for both humans and animals (Rizzo et al., 2021). By mitigating the risks posed by plant diseases, we can safeguard crop yields, reduce economic losses, and promote food security (Tariq-Khan et al., 2020). This requires a comprehensive approach that integrates plant health into the broader One Health framework, recognizing the interconnectedness of human, animal, and environmental health. Investing in plant health research, implementing effective disease management strategies, and promoting sustainable agricultural practices are essential steps in safeguarding plant health. By prioritizing plant health, we can protect our food systems, support human and animal health, and ensure a sustainable future for all.

The escalating incidence of plant disease poses a significant threat to global food security, particularly for vulnerable populations. Simultaneously, the world is grappling with a widespread human pandemic that endangers the well-being of millions. To combat these challenges and uplift disadvantaged communities, it is imperative to establish a stable and nutritious food supply. Plant diseases, both longstanding and newly emerging, are spreading rapidly, aggravated by factors such as climate change, global trade networks facilitating pathogen transmission, pathogen spillover events, and the evolution of novel pathogen strains.

Crop diseases have a substantial impact on agricultural productivity, leading to reduced crop yields, diminished food production, and economic losses for farmers. Effective pest and disease management strategies are essential for maximizing the yield potential of agricultural crops. Plant pests and diseases can cause significant damage, accounting for up to 40% loss in crop production and resulting in lower yields, compromised crop quality, and financial setbacks for farmers. According to a report by the International Plant Protection Convention (IPPC), the annual global value of crop losses due to pests and diseases is estimated to be around $220 billion.

Pests and diseases can attack plants at various stages of growth, affecting different plant parts such as leaves, stems, flowers, and fruits. They can directly damage plants through activities such as chewing, sucking, or tunneling, weakening or killing the plant, and reducing overall growth and productivity. Furthermore, pests and diseases can indirectly transmit viral, bacterial, or fungal infections, leading to symptoms like wilting, yellowing, stunting, and other detrimental effects on plant vigor and output. Fungal diseases, in particular, can cause premature plant death or decay of plant parts, including roots, stems, and fruits.

Addressing the impact of plant diseases is crucial for safeguarding crop yields and ensuring a stable food supply. Implementing effective disease management strategies, utilizing advanced detection technologies, and promoting sustainable agricultural practices are vital steps in mitigating the threats posed by plant diseases and safeguarding global food systems.

Microbial hazards in food systems: Safeguarding food security and public health

Microbes play a significant role not only in causing food

insecurity but also in jeopardizing the safety of our food supply. While plant diseases and pests can lead to reduced crop yields and food shortages, microbial contaminants pose a direct risk to the safety and quality of the food we consume.

Foodborne illnesses caused by pathogenic microbes, such as bacteria, viruses, and parasites, are a major concern worldwide. These pathogens can contaminate various stages of the food production chain, including production, processing, transportation, and preparation. Improper handling, inadequate sanitation practices, and insufficient monitoring can all contribute to the presence of harmful microbes in our food. Consuming contaminated food can have severe health consequences, ranging from mild gastrointestinal discomfort to life-threatening infections. Vulnerable populations, including children, the elderly, pregnant women, and individuals with weakened immune systems, are particularly at risk. Furthermore, the economic burden of foodborne illnesses, including medical costs and productivity losses, is substantial.

Ensuring the safety of our food supply requires a comprehensive approach that addresses microbial contamination at every stage. This includes implementing stringent hygiene practices on farms, adopting effective sanitation protocols during food processing, implementing proper storage and transportation procedures, and promoting safe food handling practices in households and food establishments.

Investments in research and technology are crucial for developing innovative solutions to detect, prevent, and control microbial contaminants. Advanced testing methods, such as DNA-based techniques and rapid diagnostic tools, can enhance our ability to identify and monitor foodborne pathogens. Additionally, improved surveillance systems and data sharing platforms enable early detection and response to outbreaks, minimizing their impact on public health.

By recognizing the risks posed by microbial contaminants and implementing robust preventive measures, we can enhance the safety of our food supply and protect consumers from foodborne illnesses. This requires collaboration among governments, food industries, researchers, and consumers to prioritize food safety, implement best practices, and promote awareness about safe food handling and consumption.

Accessibility high-quality seeds for smallholder farmers

The deployment of disease-resistant varieties is a crucial disease management strategy that has been adopted globally to address the challenges of crop diseases. Plant breeding programs aimed at developing disease-resistant varieties have become increasingly important as a way to mitigate the impact of crop diseases. Disease-resistant varieties are developed by introducing genes that confer resistance to specific diseases. This approach has been successful in addressing many diseases that were previously difficult to manage, such as rust diseases in wheat and soybean cyst nematode in soybeans. The use of resistant varieties not only reduces the incidence and severity of diseases but also reduces the need for chemical pesticides and fungicides, leading to a more sustainable approach to agriculture.

Advantages of using high-quality seeds for crop production

Followings are the advantages of using high-quality seeds for crop production

Genetic and Physical Purity

High-quality seeds ensure the preservation of desired traits and characteristics, maintaining the genetic and physical purity of crops. This leads to consistent and reliable plant performance, ensuring farmers get the expected varieties.

Optimal Plant Population

High-quality seeds contribute to achieving the desired plant population in fields. Their uniformity in size and quality allows for consistent spacing, promoting optimal plant density. This efficient resource utilization maximizes the yield potential of crops.

Resilience to Adverse Conditions

High-quality seeds are carefully selected for their ability to withstand challenging environmental conditions such as drought, heat, cold, pests, and diseases. This inherent resilience increases the chances of successful crop establishment and reduces the risk of yield losses caused by environmental stressors.

Enhanced Growth and Vigor

Planting high-quality seeds results in seedlings that exhibit vigor and fast growth. These seedlings establish quickly and grow rapidly, gaining a competitive advantage in accessing sunlight, water, and nutrients. This leads to stronger and healthier plants throughout the growing season.

Pest and Disease Resistance

Quality seeds are often bred or selected to possess resistance or tolerance to common pests and diseases. While no seed is completely immune, using high-quality seeds provides a level of protection against pest and disease incidence. This reduces the reliance on chemical interventions, promoting sustainable and environmentally friendly farming practices.

Uniform Growth and Maturity

High-quality seeds contribute to uniform growth and maturity within a crop. They exhibit consistent germination rates, emergence times, and development patterns, resulting in plants that mature at a similar pace. This uniformity facilitates efficient crop management, including irrigation, fertilization, and harvesting operations.

In summary, the use of high-quality seeds in crop production offers several advantages, including the preservation of genetic and physical purity, achieving optimal plant population, resilience to adverse conditions, enhanced growth and vigor, pest and disease resistance, as well as uniform growth and maturity. These benefits collectively contribute to improved yield potential, crop quality, and overall farm productivity. By investing in high-quality seeds, farmers can enhance their profitability, mitigate risks, and contribute to sustainable agriculture.

Enhancing awareness and access to high-quality seeds: empowering farmers for sustainable agriculture

The importance and significance of deploying high-quality seeds in agriculture may not always be well understood or communicated to the farming community. This lack of awareness can stem from various factors, including limited access to information, inadequate training and extension services, and insufficient promotion of the benefits of using quality seeds.

To address this issue, it is crucial to prioritize farmer education and outreach programs that focus on the advantages of quality seeds. These programs can include training sessions, workshops, and demonstrations where farmers can learn about the positive impacts of using high-quality seeds on their crop production and overall farming operations.

Additionally, collaboration between agricultural researchers, seed companies, and agricultural extension services is essential in disseminating knowledge about quality seeds. This can involve developing educational materials, conducting field trials to showcase the benefits of quality seeds, and establishing strong communication channels to reach out to farmers with relevant information. Farmers' associations, cooperatives, and local agricultural institutions can also play a vital role in raising awareness about the significance of deploying quality seeds. These organizations can organize farmer field days, knowledge-sharing events, and seed fairs to provide a platform for farmers to interact, learn, and access high-quality seeds directly from reliable sources.

Furthermore, policymakers and government agencies can contribute by implementing supportive policies and programs that promote the availability, accessibility, and affordability of quality seeds for farmers. This can include providing subsidies or incentives for purchasing certified seeds, facilitating the establishment of seed production and distribution networks, and incorporating seed quality standards and certification systems into agricultural regulations. By collectively addressing the knowledge gap and raising awareness about the advantages of quality seeds, we can empower farmers with the information and resources needed to make informed decisions and realize the potential benefits for their agricultural productivity and livelihoods.

In addition, there is a need to improve access to high-quality seeds, particularly for smallholder farmers who may not have the resources to purchase them. Governments and other stakeholders could work together to provide subsidies, credit, and other forms of support to smallholder farmers to help them access high-quality seeds. This could include promoting the use of seed banks, community seed production, and other initiatives to improve seed access and availability for smallholder farmers. Overall, improving awareness and knowledge about high-quality seeds and increasing access to them are essential for narrowing the yield gap between research stations and smallholder farmers' fields in Pakistan.

Enhancing soil fertility for improved agricultural productivity

The low levels of organic matter and inherent fertility in Pakistan's agricultural soils pose significant challenges to crop production. Enhancing soil fertility is critical for improving agricultural productivity as healthy soils provide essential nutrients and support plant growth. Fertile soils also have improved water retention capacity, which reduces water stress on crops, leading to

higher crop yields and better plant health. To address this challenge, interventions aimed at enhancing soil fertility are necessary. Improving soil fertility can also reduce the need for synthetic fertilizers, which can be costly and may have negative environmental impacts if not used carefully. Improving soil fertility can involve a range of measures, such as applying organic matter (e.g., compost or manure), using nitrogen-fixing crops like legumes in crop rotations, and applying appropriate amounts of fertilizers based on soil testing. Additionally, conservation agriculture practices such as minimum tillage, intercropping, and cover cropping can also help improve soil fertility and support sustainable agriculture. By enhancing soil fertility, farmers can increase crop yields, improve soil health, and reduce reliance on synthetic fertilizers, which can help reduce costs and minimize environmental impacts. Moreover, improving soil fertility can contribute to sustainable agricultural development by ensuring long-term soil health and productivity, which is essential for supporting the livelihoods of smallholder farmers and ensuring food security for the growing population of Pakistan. Nitrogen fertilizers applied to plants are not always fully used up by the plants, and a significant portion of the nitrogen can be lost through various processes. Some of the nitrogen may be lost through volatilization, which occurs when the nitrogen in the fertilizer converts to ammonia gas and escapes into the air. Moreover, leaching and runoff can occur when excess nitrogen penetrates the soil and enters surface water and groundwater, potentially leading to water pollution (Meisinger et al., 2006) and the prevalence of alkaline and calcareous soils makes it difficult for plants to access phosphorus (Memon, 1986). Additionally, zinc deficiency is a significant problem in Pakistan's soils (Zia, 1990), and other micronutrient deficiencies such as boron and iron have also been reported due to increasing cropping intensity (Rashid and Rafique, 1999). To ensure successful crop production and improve soil health, farmers in Pakistan must use fertilizers judiciously and adopt practices that increase organic matter levels and improve soil management. This could include using crop rotation, implementing soil conservation measures, and improving access to micronutrient-rich fertilizers (Abbas et al., 2021). By addressing these challenges, Pakistan's agricultural sector could become more productive and sustainable, contributing to the country's economic growth and food security.

The relationship between soil fertility and plant diseases is complex and multifaceted. Soil fertility refers to the ability of the soil to provide essential nutrients to plants for growth and development. When soil fertility is low, plants may be more susceptible to diseases, as they may not have the necessary nutrients to build and maintain strong, healthy tissues that are more resistant to pathogens. In addition to nutrient availability, soil fertility can also affect plant disease through its impact on soil microorganisms. Soil microorganisms play a critical role in maintaining soil fertility, as they decompose organic matter and release nutrients that plants can use. Some of these microorganisms, such as beneficial bacteria and fungi, can also help to protect plants from diseases by competing with or antagonizing pathogenic microorganisms. However, when soil fertility is imbalanced, with excessive nutrients or other factors that disrupt the soil microbial community, it can create conditions that favor the growth and spread of plant pathogens. For example, excessive nitrogen fertilization can promote rapid growth of plants, which may make them more susceptible to diseases. Similarly, soil compaction or waterlogging can create anaerobic conditions that can promote the growth of pathogens that thrive in these conditions. Therefore, maintaining optimal soil fertility is important for preventing plant diseases. This can be achieved through practices such as crop rotation, cover cropping, and the use of organic amendments that promote soil health and biodiversity. By maintaining healthy soils, farmers can reduce the risk of plant diseases and improve the productivity and sustainability of their agricultural systems.

Scarcity of water

Water management plays a critical role in ensuring sustainable agriculture and food security. With a rapidly growing population, increasing urbanization, and changing climate patterns, water scarcity is becoming a significant challenge for agriculture in many parts of the world. Inefficient water management practices can lead to water waste, low crop yields, reduced productivity, and economic losses. On the other hand, adopting efficient water management practices such as rainwater harvesting, drip irrigation, and improved water storage facilities can help optimize available water resources, resulting in higher crop yields, increased productivity, and improved socio-economic conditions for smallholder farmers. Therefore, improving water

management practices is crucial for sustainable agriculture and food security in the face of increasing water scarcity and climate change.

Pakistan is one of the most water-stressed countries in the world, and agriculture is the largest consumer of water in the country. Water scarcity can limit crop production and increase the cost of irrigation, affecting the profitability of farming. Agriculture is heavily reliant on irrigation, with more than 90% of the country's irrigated land using the Indus River system for irrigation. However, the availability of water is scarce and erratic, leading to water stress and a lack of optimal use of available water resources. Moreover, the water management practices in Pakistan are inefficient, leading to water waste, low crop yields, and reduced productivity. Inefficient irrigation methods such as flood irrigation, which is the most common irrigation method used in the country, result in significant water loss due to evaporation, runoff, and deep percolation. Additionally, many farmers in Pakistan do not have access to adequate water storage facilities, resulting in water shortages during the dry season. This lack of water management practices leads to lower crop yields, decreased productivity, and economic losses. To address these issues, Pakistan needs to adopt efficient water management practices such as rainwater harvesting, drip irrigation, and improved water storage facilities. Such practices will ensure optimal use of available water resources, resulting in higher crop yields, increased productivity, and improved socio-economic conditions for smallholder farmers. In Pakistan, agriculture is the largest user of water. However, much of the water used in agriculture is wasted due to inefficient irrigation practices, such as flood irrigation and open canals. This results in waterlogging, soil salinization, and reduced crop yields, ultimately threatening food security and livelihoods of farmers.

Changes in water use practices, such as irrigation scheduling, use of alternative water sources, and efficient water management techniques, can have significant impacts on crop diseases. However, the potential for these changes to affect crop diseases has often been overlooked in agricultural research and practice. Water availability is a critical factor that can affect the development and spread of crop diseases. Changes in water use practices can alter the microclimate and soil moisture conditions, which can influence the susceptibility of crops to diseases. For example, over-irrigation can lead to waterlogged soils, which can create conditions that favor the growth of root rot pathogens. On the other hand, water stress caused by under-irrigation or drought can make plants more susceptible to foliar diseases. Efficient water management practices, such as drip irrigation, can help to reduce water stress and maintain optimal soil moisture conditions, which can reduce the risk of some crop diseases. Moreover, the use of alternative water sources, such as treated wastewater or saline water, can also affect crop diseases, as these water sources may contain pathogens or salts that can affect plant health. Therefore, it is important for agricultural researchers and practitioners to consider the potential impacts of changes in water use practices on crop diseases, and to develop strategies that can mitigate any negative impacts. This can help to ensure that agricultural production is sustainable and resilient, and that crop diseases do not pose a threat to food security and livelihoods (Swett, 2020).

To address these challenges, sustainable water management practices such as drip irrigation, sprinkler irrigation, and precision irrigation can be implemented. These practices can help improve water-use efficiency, reduce water losses, and conserve water resources. Furthermore, water harvesting techniques such as rainwater harvesting and conservation of small water bodies can be used to supplement existing water resources. Moreover, education and awareness-raising campaigns can help promote sustainable water use practices among farmers, such as crop rotation, intercropping, and appropriate irrigation scheduling. Additionally, effective governance structures, policies, and regulations can also help ensure sustainable water use practices, including water allocation, water pricing, and water rights.

In conclusion, sustainable water management practices are essential for ensuring the long-term sustainability of agriculture in Pakistan. By improving water-use efficiency, conserving water resources, and promoting sustainable agricultural practices, sustainable water management can support agricultural production, improve farmers' livelihoods, and enhance food security while protecting the environment

Effective pest and disease management strategies: integrated pest management and sustainable practices

Effective pest and disease management tactics, such as

integrated pest management, cultural practices, resistant crop varieties, and proper pesticide use, can help minimize the damages caused by pests and diseases and reduce the risks of crop losses. Integrated pest and disease management (IPM) is a holistic approach to managing pests and diseases that aims to minimize the use of synthetic pesticides and promote sustainable and environmentally friendly practices. This approach involves the use of multiple control methods, including cultural, biological, and chemical methods, to manage pest and disease populations (Mukhtar et al., 2023).

Cultural control methods are a key component of integrated pest and disease management and involve modifying the growing environment or crop management practices to prevent or reduce pest and disease populations. Crop rotation, intercropping and planting disease-resistant varieties are all examples of cultural control methods. Crop rotation involves alternating the types of crops planted in a field over time to reduce the buildup of pest and disease populations in the soil (Ijaz et al., 2019). Intercropping involves planting multiple crops together in the same field to reduce pest and disease pressure (Vaquié, 2019), while planting disease-resistant varieties involves selecting crop varieties that are less susceptible to pest and disease damage (Maheshwari et al., 2020).

Chemical control methods involve the use of synthetic pesticides, which are chemical substances designed to kill or control pests and diseases (Tudi et al., 2021). These pesticides can be applied in various ways, such as spraying, dusting, or baiting, and are intended to target specific pests or diseases while minimizing harm to other organisms. Chemical control methods have been widely used in agriculture and other industries for many years, and they can be effective in controlling pest populations and reducing crop damage (Bernardes et al., 2015). However, there are also concerns about the potential negative impacts of chemical pesticides on human health and the environment. Some pesticides can be toxic to humans and other non-target organisms, and can accumulate in soil, water, and food chains over time (Hernández et al., 2013).

To address these concerns, there has been a growing interest in developing more sustainable and environmentally friendly alternatives to chemical control methods, such as biological control, cultural control, and integrated pest management. These alternative methods aim to reduce the reliance on chemical pesticides and promote more holistic and sustainable approaches to pest and disease management.

While this method can be effective, it also has potential negative impacts on the environment and human health. In IPM, chemical control is used only when other control methods are not effective, and proper pesticide use and safety precautions are followed. IPM involves regular monitoring and scouting of crops to detect and identify pest and disease populations. Based on the information gathered, appropriate control measures are implemented to manage the populations effectively. By combining multiple control methods and minimizing the use of synthetic pesticides, IPM can help reduce the risk of crop losses and promote sustainable agriculture practices.

Deployment of resistant crop varieties is a method of controlling diseases and pests by selecting and cultivating crops that have built-in resistance to specific pests or diseases.

This is often achieved through traditional breeding methods or genetic engineering techniques, which involve introducing genes that confer resistance into the plant's genome. Resistant crop varieties offer several advantages over chemical and other control methods. They can be more sustainable and environmentally friendly, as they do not rely on the use of synthetic pesticides. They can also be more cost-effective in the long run, as farmers do not need to purchase and apply pesticides regularly. Additionally, resistant crop varieties can help to preserve biodiversity by reducing the need for habitat destruction and other practices associated with chemical control methods.

However, the success of resistant crop varieties can be limited by several factors, including the ability of pests and diseases to adapt and overcome resistance over time, and the potential unintended consequences of genetic modification. Therefore, a comprehensive pest and disease management strategy may involve a combination of different control methods, tailored to the specific needs of each situation

Maximizing food availability from harvest to table: an approach to attain food security

Mitigating postharvest losses is a crucial strategy to ensure food security, especially in developing countries where food loss and waste are significant challenges. Postharvest losses refer to the losses that occur after crops are harvested, during storage, transportation, and processing (Kumar and Kumar, 2014). Postharvest losses can occur due to a variety of factors, such as

inadequate storage facilities, poor handling practices, pests and diseases, and inadequate processing facilities (Parfitt et al., 2010). These losses can have significant economic and social impacts, as they can reduce the income of farmers, increase food prices, and limit access to food for consumers.

To address this issue, various measures can be implemented. Firstly, farmers can adopt better harvesting techniques, such as selective picking or timing the harvest to coincide with peak ripeness. This can help to reduce the amount of produce that is discarded due to spoilage or over-ripeness. Secondly, farmers can explore alternative markets for their produce, such as local food banks or processing facilities that can turn surplus produce into value-added products. By diversifying their customer base, farmers can ensure that their entire crop is utilized, rather than being discarded. Thirdly, governments and NGOs can support farmers by investing in post-harvest infrastructure, such as cold storage facilities or transportation networks that enable farmers to reach distant markets. This can help to reduce the amount of produce that is lost due to inadequate storage or transport conditions. Ultimately, reducing wastage of produce after harvesting requires a multi-pronged approach that involves farmers, consumers, and policymakers. By working together, we can create a more sustainable and efficient food system that benefits everyone**.**

By reducing postharvest losses, more food can be made available for consumption, which can improve food security and reduce food waste. This can be achieved through various measures, such as promoting sustainable agriculture practices, improving post-harvest handling and storage systems, developing value addition and food processing industries, strengthening distribution and marketing systems, and promoting healthy eating habits. By implementing these strategies, we can increase food production, reduce food waste, and improve access to nutritious and affordable food for all. Ultimately, a sustainable food system that maximizes food availability from harvest to table is critical to ensuring food security and promoting economic and social development (Kader, 2005).

A holistic approach to food security: strategies for improving access, sustainability, and community support

Other strategies to ensure food security may include improving access to credit and financial services for farmers, promoting sustainable farming practices, and developing policies that support small-scale farmers and rural communities. A holistic approach to food security that addresses the entire food system, from production to consumption, is essential to ensure that everyone has access to safe, nutritious, and affordable food.

CONCLUSION

The agricultural sector in Pakistan is a critical contributor to the country's economy and provides employment opportunities for a significant portion of the population. However, the sector faces several challenges that require targeted interventions, including water scarcity, land degradation, low productivity, and climate change. To address these challenges, it is essential to improve farmers' awareness and knowledge about high-quality seeds, improve their access to these seeds, and promote better soil management practices efficient water management practices and pest and disease management. Pest and disease management is essential for successful crop production as they can cause significant economic losses and impact food security. However, the use of chemical pesticides in pest and disease management can have negative impacts on the environment and human health. Pesticides can contaminate water sources, harm non-target organisms, and lead to the development of pesticide-resistant pests and diseases. This highlights the need for more sustainable and environmentally friendly pest and disease management alternatives. Integrated pest and disease management is a strategy that combines different control methods to manage pests and diseases sustainably. It includes the use of cultural practices such as crop rotation, intercropping, and the use of resistant crop varieties, as well as biological controls, such as the use of natural predators and parasites. Proper pesticide use is also a component of IPM, where pesticides are only used when necessary and in a targeted and safe manner. Adopting sustainable pest and disease management practices can help minimize the negative impacts of chemical pesticides while promoting environmental sustainability and human health. Sustainable practices can also help to minimize economic losses and improve crop productivity, benefiting farmers and contributing to food security. Continued research and development of new pest and disease management strategies are necessary to ensure

that farmers have access to the most effective and sustainable practices. In summary, effective pest and disease management is crucial for successful crop production, but it is essential to manage them sustainably to minimize negative impacts on the environment and human health. By adopting sustainable pest and disease management practices and continuing to develop new strategies, farmers can improve crop productivity, contribute to food security, and promote environmental sustainability and human health. Providing support to smallholder farmers through education, subsidies, and credit can also help narrow the yield gap and improve crop yields and farmers' livelihoods. By addressing these challenges, Pakistan's agricultural sector can achieve greater productivity, contribute to the country's economic development, and ensure food security for the population.

AUTHORS' CONTRIBUTION

AA conceived the idea of writing the review; SM, MAH and AA collected and compiled the literature; AA wrote the manuscript; AA guided and provided feedback to the coauthors; All the authors proofread the manuscript; AA polished and submitted the manuscript for publication.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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